An Inexpensive Capillary Flow Board For Olfactometer Studies

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ABSTRACT

An inexpensive, easy-to-construct capillary flow board was developed by utilizing polypropylene tubing for the manifolds and Tygon tubing for the manometers. This modified capillary flow board provides multiple port outlets to process several test gases simultaneously and, in addition, produces a constant and uniform rate of gas flow. Estimated cost of the flow board, excluding air pump, is $45.00.

Research studies that involve olfactometer tests require gas flow meters that 1) provide a steady and uniform gas flow, 2) enable metering of many gas mixtures and 3) possess multiple outlet ports. Gas flow meters such as the capillary-ball flow meter provide steady and uniform gas flow, usually metering through a single outlet port, and are calibrated to a standard gas but require correction factor recalibration for other gases.

We designed an inexpensive capillary flow board which offers a high degree of precision for controlling gas flow rates and has multiple outlet ports. The standard glass or copper tubing used for the manifolds was replaced by polypropylene tubing and Tygon tubing was used in place of the fragile glass manometers found on earlier designs (Pratt et al. 1960).

The constructed capillary flow board was successfully used to study the movement of the Chinese rose beetle, *Adoretus sinicus* Burmeister, toward plant volatiles (Arita et al. 1988). An olfactometer system similar to that described by Chang and Hsu (1982) was constructed using the capillary flow board. The flow board allowed us to adjust as well as monitor the air flow for the beetles at all times. Air was pumped into the manifolds and metered through 2 outlet ports of glass capillary tubing which flowed into cylinders containing the test plants and controls. Each cylinder was attached to the ends of a Y-shaped olfactometer as described by Chang & Hsu (1982). Air was metered through the olfactometer at 10, 20 and 40 cc per min and the movement of the beetles toward each cylinder was recorded.

MATERIALS AND METHODS

Construction. The schematic diagram (Fig. 1) illustrates the design of the capillary flow board. The main manifold (label in diagram) was constructed with polypropylene tubing (1.2 cm inside diameter (ID)) and polypropylene microtubing (0.25 cm ID). The polypropylene microtubing

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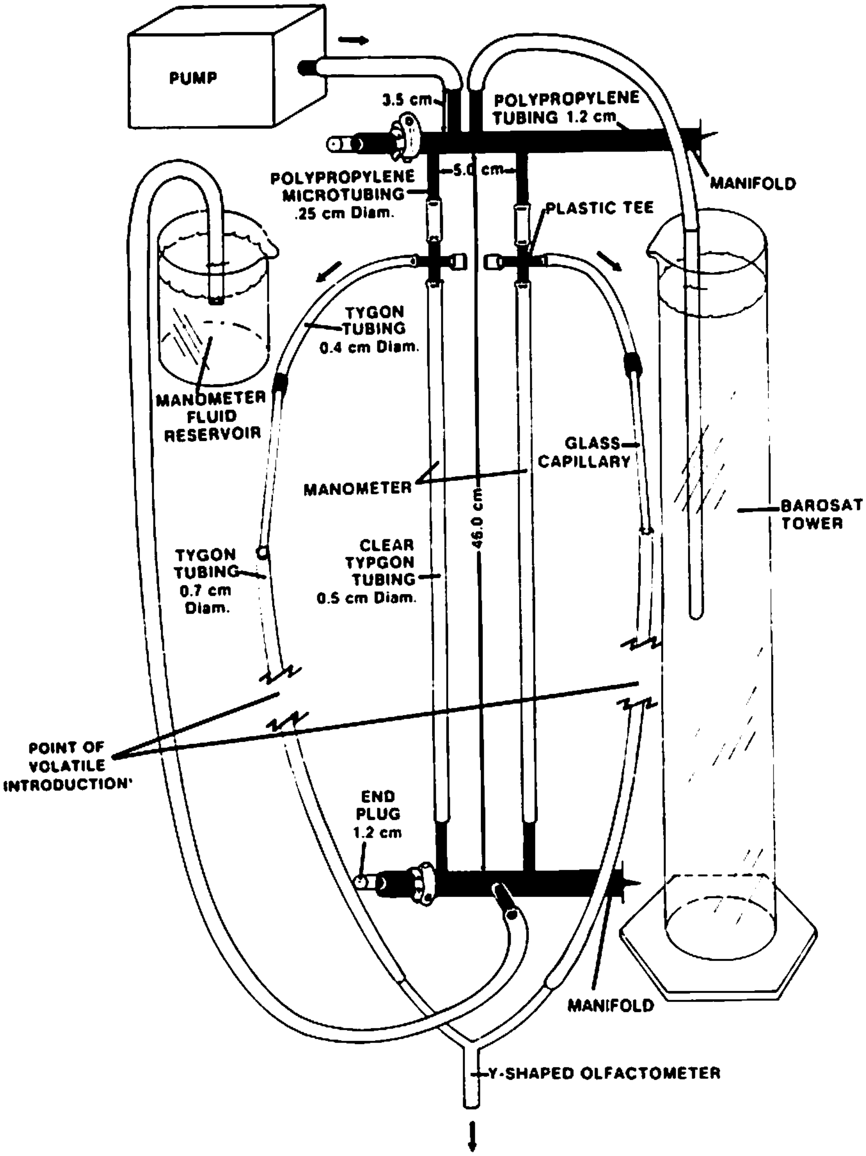

FIGURE 1. Schematic diagram of capillary flow board. [1]Designates the approximate location of the volatile introducing system. The design of the system to introduce volatiles is highly dependent on the volatile used, therefore the area is left open to accept different types.

was attached to the polypropylene tubing through a hole made with a puncher tool (used for making microtubing irrigation joints in polypropylene tubing). Immediately after punching a hole into the polypropylene tubing, a 5.0 cm length of polypropylene microtubing was inserted into the hole. Due to the "plasticity" of the polypropylene, reclosure of the hole around the microtubing resulted in a water and air tight seal. Additional 5.0 cm lengths of microtubing were inserted at 5.0 cm intervals on the polypropylene tubing for additional outlets (our unit had 10 outlets). Two additional ports were required on the upper manifold; one port served as an inlet from the pump and a second was an outlet to the barosat tower. These ports were made as described above using 5.0 cm lengths of microtubing. The connections to the air pump (Silent Giant, Silent Giant Manufacturing Co., Calif.), a standard diaphragm type aquarium pump, and the barosat tower were made with clear Tygon tubing (0.7 cm ID). The Tygon tubing to the barosat tower was connected to a pipet (1.0 ml). The barosat tower was a 1000 ml graduated cylinder filled with distilled water.

The manometer consisted of a 40.0 cm length of clear Tygon tubing (0.5 cm ID) connected to a plastic tee. The base was connected to the lower manifold which was a duplicate of the upper manifold, except that its only outlet was to the manometer fluid reservoir. The reservoir was a 100 ml glass beaker filled with distilled water. A plastic tee joint which served as the gas outlet port was inserted 6.0 cm below the base of the upper manifold. Gas from the outlet port was channeled through a glass capillary tubing to an arm of the Y-shaped olfactometer. All connections were made with 0.4 cm ID Tygon tubing. The connections were repeated on the adjacent manometer and attached to the other arm of the Y-shaped olfactometer. Outlet ports on the other manometers were stoppered when not in use. The entire system was supported by clamping the manifolds to a wooden stand.

The pressure of the gas entering the manifold was regulated with the barosat tower. Increasing the depth of the barosat tubing (1.0 ml pipet) increased the gas pressure (head pressure) in the manifold. The head pressure in the manifold was monitored by the fluid height change in the manometers. The initial height of the manometers was also adjusted by regulating the height of the manometer fluid reservoir.

In addition to regulating head pressure by the barosat, the rate of gas flow was also regulated by the length of the glass capillary tubing which restricted gas flow. Increasing the capillary tube length slowed flow rate, and decreasing the length increased the rate.

To calibrate the system, we suggest that the head pressure be kept constant and the flow rate be adjusted by the length of the capillary tubing. The flow rate of each capillary tubing can then be labeled and further calibration is not required, provided the pressure remains constant.

Gas flow rates were measured by utilizing a standard 10 ml pipet which was immersed in soap solution to form a soap lens within the pipet. The pipet was then connected to the outlet port of the capillary tubing and rate of gas flow was calculated by the speed of the lens movement (cc per min).

Test volatiles are introduced into the capillary flow board system (Fig. 1) in the area labeled "Point of Volatile Introduction". Since our capillary flow board is designed to be used with many different volatiles which possess different methods of introduction into a pressurized system, we have indicated the point of introduction with a blank area. In our studies with ethylene (Arita et al., 1988), we utilized an ethylene diffusion system as described by Saltveit (1978). In this system, a predetermined length of Tygon tubing is exposed to ethylene. Ethylene diffuses through the walls of the tubing entering the air stream at a very uniform rate. Exact concentration of ethylene in the air stream was determined by gas chromatography.

The tubing, which connects the volatile introducing apparatus to the olfactometer, should be replaced with new tubing after each use to avoid contamination. Molecular adhesion of volatiles to the surface of the tubing is common with many materials including plastics used in the construction of Tygon tubing. This contamination may produce artifacts in results if the tubing is not replaced.

We determined the effect of head pressure and glass capillary tubing length on flow rate of air. Flow rates were measured at 3.0, 4.0 and 5.0 cm H_2O head pressure and 8, 10, 12, 16 and 18 cm lengths of glass capillary tubing. Ten replicated measurements were taken for each treatment. Flow rates at each head pressure level were curve-fitted by second or third order regression analysis. Stepwise regression analysis as described by Neter & Wasserman (1974) was used to develop a general model that would predict flow rates at all head pressures and capillary tubing lengths tested. All measurements were adjusted to standard temperature and pressure.

RESULTS AND DISCUSSION

The effect of head pressure on air flow rate with various lengths of the glass capillary tubing is illustrated in Fig. 2. Air flow rate increased as head pressure increased. Increasing the capillary tube length decreased air flow rate due to increased resistance in the capillary tubes. The trend in the air flow was consistent over all head pressures studied. The model of the relationship between head pressure and capillary tube length is expressed as:

$$Q = 175.77 + 9.12L - 110.88\,L^{0.5} + 96.78P^{0.5}$$

Q = Air Flow Rate (cube cm per min)
L = Capillary Tube Length (cm)
P = Head Pressure (cm H_2O)

The R-squared value for the stepwise regression model was 0.965.

Polypropylene tubing used in drip-irrigation systems and clear Tygon tubing are readily available components that can be easily adapted for construction of this economical capillary flow board system for olfactometer studies. This system is less expensive than commercially available units and can be modified to fit the specific needs of the researcher. The total material cost for the capillary flow board, excluding air pump, was $45.00.

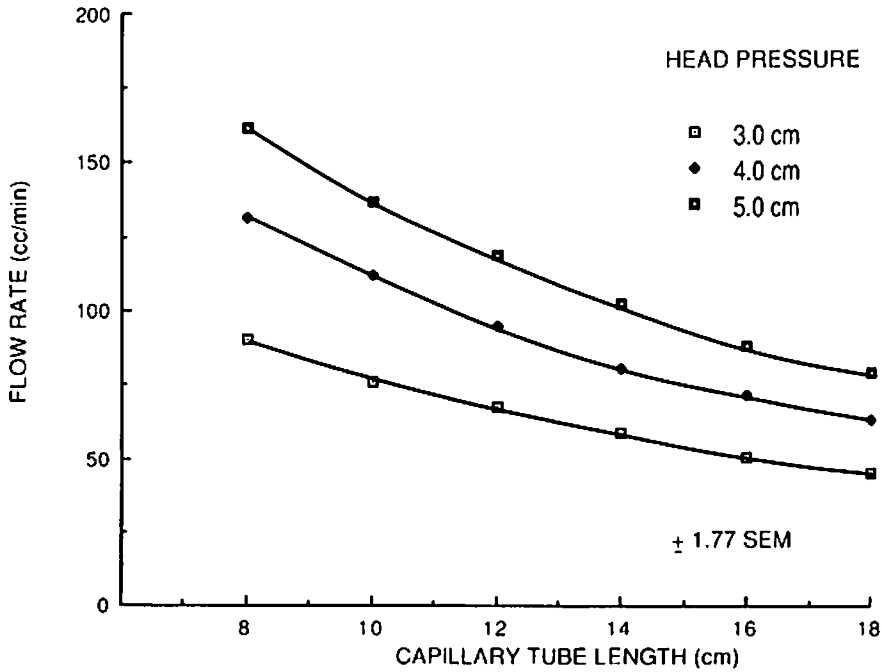

FIGURE 2. Influence of head pressure and glass capillary tube length on the flow rate of air.

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